

# CHANGES IN BIOMASS OF SIX DOMINANT PLANT SPECIES DURING OLDFIELD SUCCESSION IN SOUTHEASTERN INDIANA<sup>1</sup>

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## ABSTRACT

A study of the secondary succession in abandoned corn fields based on biomass of six selected common plant species was made in an area of alluvial soils in southeastern Indiana. It was found that during the first year after abandonment the fields were dominated by the winter annuals *Erigeron annuus* and *E. canadensis*. The second year the fields were dominated by *Aster ericoides*, a perennial, and the third year and for several years thereafter by *Solidago canadensis*, also a perennial. By the ninth year all of these early seral dominants had been either eliminated or had had their importance much reduced by the invasion of many other species.

## INTRODUCTION

Man's impact upon vegetation has been one of intensive use and/or continual disturbance, making the weed community one of the most prevalent of all our plant-community types. However, very few quantitative studies of weed communities have been reported for the state of Indiana (Petty and Jackson, 1966) and only the studies of Larson (1935), dealing with shrubby species, McCormick (1968) on revegetating vineyards, and Toye and Wistendahl (1972) have been reported for Ohio.

The early secondary succession of abandoned croplands has been shown for southern Illinois by Bazzaz (1968) and for the piedmont region of North Carolina by Keever (1950) to be dominated by a few common weedy species such as *Erigeron canadensis*, *E. annuus*, *Digitalia sanguinalis*, *Aster pilosus*, *Solidago* sp., and *Ambrosia elatior*. These studies and others substantiate reports that early seral stages of oldfield succession are generally short-lived and that the species composition of successional sequences are usually predictable.

The previously mentioned investigations measured dominance of early-seral-stage species using data on canopy coverage and frequency (Bazzaz, 1968) or on canopy coverage and density (Keever, 1950). The purpose of this study was to quantify, on a biomass basis, successional changes for six early-seral-stage plant species as they occurred in selected abandoned corn fields on alluvial soils of southeastern Indiana.

## METHODS

Abandoned corn fields along the valley of the East Fork of the Whitewater River in Franklin County, Indiana, were selected for study. This area was chosen because 10,000 acres of cropland and forested slopes had been purchased by the Army Corps of Engineers to be flooded by the creation of the Brookville Reservoir. This land seemed particularly suitable for study because fields at various stages of succession were available in close proximity to one another.

Soils of all study sites were alluvial in origin and varied from clay loams to sandy loams of the Fox and Genesee soils series (Rogers *et al.*, 1950). Many fields from this region were observed, but only fields that did not show signs of recent disturbance were chosen for quantitative studies. The past owners or tenants of selected fields were located and questioned to determine the year of abandonment, fertilizer program used, type of crop rotation used, and last crop grown. Based on this information, eight sites, on which corn was the last crop, were selected for

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intensive studies. Sampling was done in five fields which had been abandoned for one year (e.g., study was made during first growing season after abandonment), in two fields which had been abandoned for two years, and in one field which had been abandoned for nine years.

Utilizing the impressions from our own observations and the data from the studies of Bazzaz (1968) and Keever (1950), six seemingly dominant plant species were selected for in-depth study. The species investigated were *Erigeron canadensis*, *E. annuus*, *Aster ericoides*, *A. lateriflorus*, *Solidago canadensis*, and *Daucus carota*. Nomenclature of plant species follows that of Gleason (1952).

Each field was sampled in mid-July, 1969, by clipping all the above-ground vegetation of the six plant species to be studied in fifteen 0.5 m<sup>2</sup> quadrats. Location of these quadrats was determined by throwing the quadrat frame into fifteen different areas of each field, thus attempting to ensure a chance sampling of each site. The vegetation clipped from each quadrat was separated according to species, put into labelled bags, and oven-dried at 105°C for 24 hours. Dominance of plant species was assigned on the basis of oven-dried weight (biomass).

This study was originally designed to be a one-year study. However, data collected during a different study the following year (1970) provided additional information which seemed appropriate to include. One of the 1969 two-year-old oldfields was resampled as a three-year-old oldfield during mid-July of 1970. This field was again sampled by clipping all the selected species from selected quadrats and establishing dominance on the basis of biomass. The quadrat size for the 1970 study was increased to 1 m<sup>2</sup> and the number of samples taken was increased to twenty. Sample dates were comparable for the two study periods; thus to facilitate comparisons the biomass data for both years were converted to grams/m<sup>2</sup>.

#### RESULTS

The quantitative results of the mid-July sampling of the different-aged corn fields show considerable difference in species dominance with increasing years since abandonment (fig. 1). During the first year after abandonment the biomass of *Erigeron annuus* and *E. canadensis* was high. *Erigeron annuus* was in full flower at the time of sampling; *E. canadensis* was still in a vegetative state. *Aster ericoides*, *A. lateriflorus*, *Solidago canadensis*, and *Daucus carota* were present the first year, but contributed only minimally in terms of their biomass to the oldfield community.

In the second year after abandonment there was a substantial decline in the biomass of *Erigeron annuus* and *E. canadensis* and a concomitant increase in the biomass of *Aster ericoides*, *A. lateriflorus*, and *Solidago canadensis* (fig. 1). In the third-year *Solidago canadensis* was the dominant species (fig. 1). The first-year dominant *Erigeron annuus* was present but much reduced in size and biomass, and *E. canadensis* was only rarely found. Both species of *Aster* were also much reduced in biomass.

In the field abandoned for nine years *Solidago canadensis* was still the dominant species. Although it was dominant in terms of biomass, it averaged about a foot in height in the nine-year-old field as compared with an average height of five feet or more in the three-year-old fields. The herbaceous vegetation of the nine-year-old field was very diverse, with *Daucus carota* and *Aster ericoides* having only slightly less biomass than the dominant *Solidago*. Tree seedlings (*Acer Fraxinus*, and *Platanus*) had become established in this stage.

#### DISCUSSION

A pattern of succession for the six dominant plant species can be established for these different-aged abandoned corn fields of southeastern Indiana (table 1). This pattern, developed from the biomass data of figure 1 and the observations of

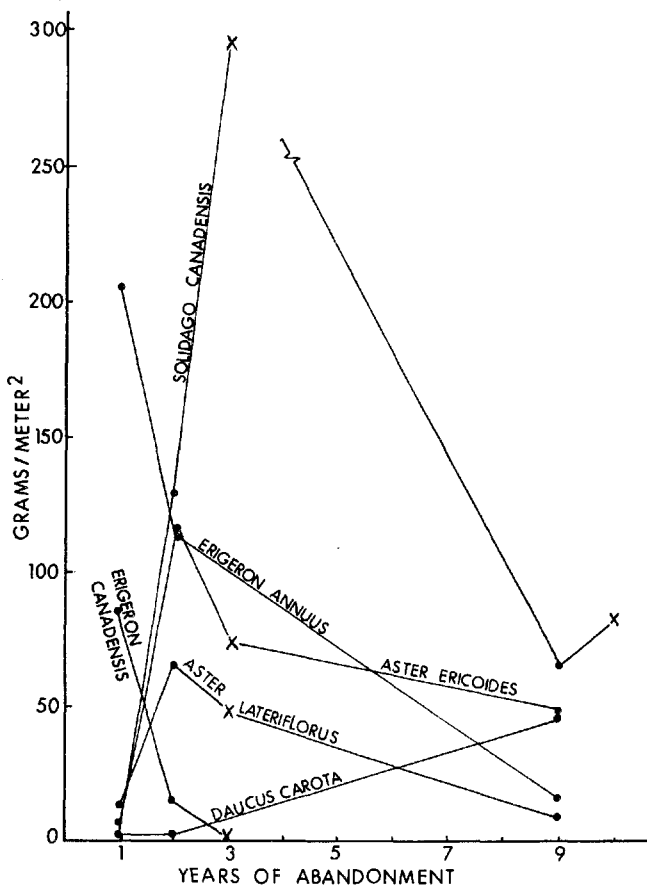


FIGURE 1. Biomass of dominant species in the succession of abandoned corn fields in south-eastern Indiana. Points represent means of five one-year-old fields, two two-year-old fields, and one field each for the three- and nine-year-old fields. All samples were taken in mid-July. Dots indicate data from fifteen, 0.5-meter<sup>2</sup> quadrats in 1969 and crosses data from twenty, 1.0-meter<sup>2</sup> quadrats in 1970.

many fields during this study, appears to be at least partially related to the growth habits of the species involved. All organisms inhabiting a given area are interdependent and, in addition, each individual's growth cycle is geared to any alterations in the environment (Swieringa and Wilson, 1972).

*Erigeron annuus* and *E. canadensis*, the dominants in the one-year-old oldfields, are well adapted to early invasion of abandoned croplands in that their seeds germinate in the later summer and early fall, forming rosettes during the winter (Bazzaz, 1968; Swieringa and Wilson, 1972). Existing as winter annuals, these two species get an early start in the following growing season, thus gaining an advantage over other species with seeds that do not germinate until the first growing season after abandonment.

*Erigeron canadensis* is also an early invader elsewhere. This species is the dominant in most first-year fields in the Piedmont of North Carolina (Oosting, 1942). In Tennessee this species is codominant with *Ambrosia elatior* (Quarterman, 1957) during the first stage of oldfield succession. Keever (1950) reports that, during the first year of abandonment of a field in North Carolina, *Erigeron*

*canadensis* and *Digitaria sanguinalis* are almost always dominant, but that *Erigeron*, being a plant four to six feet tall, is the more conspicuous species. The present study, together with the phenological investigations of Swieringa and Wilson (1972) on early stages of oldfields in this region, suggests that *Erigeron canadensis* and *E. annuus* are the major dominants of first-year oldfields throughout south-eastern Indiana. Other pioneer species, such as *Ambrosia artemisiifolia* and *Setaria faberii*, were observed to be present as subdominant species in these fields.

TABLE 1  
The secondary succession on abandoned corn fields in southeastern Indiana

Year	Species <sup>1</sup>
1	ERIGERON ANNUUS, ERIGERON CANADENSIS, ( <i>Setaria faberii</i> , <i>Ambrosia artemisiifolia</i> )
2	ASTER ERICOIDES, (SOLIDAGO CANADENSIS), <i>Erigeron annuus</i> , <i>Aster lateriflorus</i> , <i>Erigeron canadensis</i>
3	SOLIDAGO CANADENSIS, <i>Aster ericoides</i> , <i>Aster lateriflorus</i>
4	[SOLIDAGO CANADENSIS]
5-6	[SOLIDAGO CANADENSIS] still dominant but on its decline
7-10	*Field is now quite diverse, containing DAUCUS CAROTA, <i>Acer negundo</i> , <i>Aster ericoides</i> , <i>Aster lateriflorus</i> , <i>Oenothera biennis</i> , <i>Platanus occidentalis</i> , <i>Solidago canadensis</i> , <i>Solidago gigantea</i> , <i>Ulmus americana</i> , and many other species

<sup>1</sup>Capital letters = dominant plant(s)

Lower-case letters = important plants in the community

Parentheses = present in some cases

Brackets = estimation based on observation

Asterisk = estimation based on sampling and observation

*Aster ericoides* attains dominant status during the second year of abandonment in these fields. Keever (1950) attributes the delay in assuming dominance of this species, called *Aster pilosus* by Keever, to the fact that *Aster* seeds mature late in the fall and thus cannot germinate until the following spring. Thus they can not compete with the well-established *Erigeron* rosettes during the first year of abandonment. However, with the demise of *Erigeron* dominance during the second year of abandonment, the *Asters* have an open habitat available to them. Bazzaz (1968) also reports that an aster, *Aster pilosus*, dominates second-year oldfields of southern Illinois. In the region of the present study, *Aster ericoides* and also *A. lateriflorus* disseminate their seeds during mid-fall, and seedlings do not appear until early June (Swieringa and Wilson, 1972). In the first-year fields, these asters were found only as rosettes, with only a few mature individuals. They reach their peak during the second year and decline gradually in biomass during the later stages of succession.

Although the major species of *Aster* (*A. ericoides*) reported here (and also by Oosting, 1942) is different from that (*A. pilosus*) reported by Keever (1950) and Bazzaz (1968), the behavior patterns of both species in oldfield succession are very similar. In addition it should be noted that, although the major species of *Aster* in our study sites was typically *Aster ericoides*, many individuals possessed identifying characters of both *A. ericoides* and *A. pilosus*. The taxonomic ambiguity of these two taxa and their very similar ecological roles may indicate that they are both members of a single large diverse population here. Certainly more in-depth investigations are necessary for an understanding of this particular problem, an understanding that is not essential for the present ecological study.

*Solidago canadensis* sometimes shares the dominance in second-year abandoned fields in this region. Our observations and measurements indicate that this

species is present, but is of little importance during the first year after abandonment. By the second year it may be a codominant with *Aster ericoides* and *Erigeron annuus*, and by the third year it is the dominant plant species. *Solidago canadensis* then generally remains in these fields as the dominant plant species until the seventh or eighth year following abandonment.

It is during the second year following abandonment that the dominant vegetation of these oldfields changes from annual to perennial forms. The pattern of behavior for *Solidago canadensis* here is similar to that for *S. nemoralis* reported by Bard (1952) for the piedmont of New Jersey, by Bazzaz (1968) for southern Illinois, and by Drew (1942) for Boone and Callaway Counties, Missouri. Quarterman (1957) states that *Solidago altissima* becomes a dominant on abandoned croplands in the central basin of Tennessee during the third year after abandonment and remains a dominant until the fifteenth year. Thus it appears that different species of *Solidago* invade abandoned croplands during the early stages after abandonment and play similar ecological roles in many diverse geographical locations.

After the sixth or seventh year of abandonment these fields increase greatly in species diversity and show a decrease in the dominance of any single species. *Solidago canadensis* and *Aster ericoides* share the dominance of these later stages with *Daucus carota*, a subordinate species of the early seral stages. The decline of *Solidago canadensis* and the increase of *Daucus carota*, with its showy white inflorescence, makes this species quite conspicuous in the seven- to ten-year stages of abandoned croplands in this region.

Most of the other oldfield investigations mentioned in this paper make no reference to *Daucus carota*. However, Stevens (1940), in his studies on upland soils of the New Jersey pine barrens, does list *D. carota* as an important herbaceous plant species in those communities. Stevens states that *D. carota* is present in that region in the pine-grass stage, which is characteristic of oldfields abandoned some 5 to 15 years. *Daucus carota* is also reported as being present in southeastern Ohio in fields abandoned for 7 and 10 years, but not in fields abandoned for 25 years (Toye and Wistendahl, 1972). This taxon appears to be more restricted in its presence in oldfields than the previously mentioned species such as *Erigeron canadensis*, *E. annuus*, the species of *Aster*, and the species of *Solidago* that appear in oldfield seres of diverse geographical locations.

The greater ubiquity of early-seral-stage species than of species of later stages of abandoned croplands is documented by Haug and Van Dyne (1968). They state: (1) that usually the first plants to invade abandoned fields are annual forbs and some biennials or perennials, (2) that the species composition of early seral stages in different regions is closely parallel regardless of the final stage, and (3) that gradually the species compositions of diverse regions diverge, and parallels end among widely varying sites and biomes.

#### SUMMARY

The secondary succession in abandoned corn fields in southeastern Indiana, as quantified on a biomass basis for six common plant species, was found to be similar to that reported by Bazzaz (1968) for southern Illinois and by Keever (1950) for the Piedmont of North Carolina. It was found that during the first year after abandonment the fields were dominated by the winter annuals *Erigeron annuus* and *E. canadensis*. The second year the fields were dominated by *Aster ericoides*, a perennial, and the third year and for several years thereafter by *Solidago canadensis*, also a perennial. By the ninth year all of these early seral dominants had been either eliminated or had had their importance much reduced by the invasion of many other species. On the basis of the survey of these six species, it appears that there is a great deal of similarity in the early secondary succession of abandoned fields among such geographically diverse places as North Carolina, New Jersey, and southern Indiana and Illinois, and that ecologically similar positions in these oldfields are occupied by similar taxa.

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